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PRINCIPAL INVESTIGATOR: Doctor Helene M. Hoffman

CONTRACTING ORGANIZATION: University of California, San Diego
La Jolla, California 92093-0934

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The University of California, San Diego (UCSD) School of Medicine's (SOM) Learning Resources Center (LRC) is developing a virtual world to provide a compelling learning environment and a valuable paradigm for navigating through medical knowledge. It combines 3-D anatomic models (based on the Visible Human TM dataset) with supporting 2-D media (e.g., diagnostic imagery, surgical videos, etc.) to establish a dynamic learning environment that integrates spatial knowledge (VR) with extant multimedia (MM) resources. Case-based scenarios promote exploration, discovery, and active learning by enabling users to "dissect" 3-D anatomic models while accessing supporting resource elements. Exercises are organized in a 3-D "Study Guide" that supplies: 1) an interactive Table of Contents for flexible non-sequential access to the case material; 2) descriptive text which provides an organized presentation of key concepts; and 3) suggested exercises and exploratory actions. The LRC is also evaluating the VR-MM environment in order to optimize learning outcomes, training transfer, and cost-effectiveness. These experiments are being designed to evaluate important VE system design issues including degree of immersion and affect on users' perception of depth in virtual space as indexed by perceptual-motor task performance.

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Dennis Hoffman 10/14/97

PI - Signature Date

VR/MULTIMEDIA SYNTHESIS (VRMMS), PHASE II

ANNUAL REPORT

1-OCT-1996 THROUGH 30-SEP-1997

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INTRODUCTION:

The University of California, San Diego (UCSD) School of Medicine's (SOM) Learning Resources Center (LRC) is developing a virtual world to provide a compelling learning environment and a valuable paradigm for navigating through medical knowledge. It combines 3-D anatomic models (based on the Visible Human™ dataset) with supporting 2-D media (e.g., diagnostic imagery, surgical videos, etc.) to establish a dynamic learning environment that integrates spatial knowledge (VR) with extant multimedia (MM) resources. Case-based scenarios promote exploration, discovery, and active learning by enabling users to "dissect" 3-D anatomic models while accessing supporting resource elements. Exercises are organized in a 3-D "Study Guide" that supplies: 1) an interactive Table of Contents for flexible non-sequential access to the case material; 2) descriptive text which provides an organized presentation of key concepts; and 3) suggested exercises and exploratory actions. The LRC is also evaluating the VR-MM environment in order to optimize learning outcomes, training transfer, and cost-effectiveness. These experiments are being designed to evaluate important VE system design issues including degree of immersion and affect on users' perception of depth in virtual space as indexed by perceptual-motor task performance.

PLANS:

The primary goal for the upcoming year is to complete the basic evaluation phase of this project. This will be accomplished using a one year, no-cost extension to our DARPA grant. The full-time psychologist/evaluator, proposed in the original (and subsequently not fully-funded) budget was not hired. Instead, we have contracted two consultants: 1) Larry Hettinger, Ph.D. of Logicon to design the experimental protocols necessary to define and evaluate 3-D perception metrics and 2) Karen Garman, Ed.D. of UCSD to assess the educational outcomes and training transfer. In addition Erik Viirre, M.D., Clinical Instructor in UCSD's Department of Surgery, and a specialist in the neurophysiology of vision and perception, is joining the developmental team on a part-time basis and will be assisting with the design and testing of subjects. Data gathering from subject testing will occur between January - June,1998, with a Final Report available September 30, 1998.

ACCOMPLISHMENTS:

1. *VRMMS architecture formalized*

   - The name **"VisualizeR"** was selected to describe the VRMMS software architecture developed by UCSD SOM LRC. "Anatomic VisualizeR©" describes the first application under development using this architecture.

2. "Anatomic VisualizeR©" *and a prototype anatomy lesson were presented at MMVR 5, January 1997:*

   - Dzung Vu, M.D., visiting anatomist and surgeon from the University of New South Wales in Sydney, Australia spent a mini-sabbatical at the LRC assisting in the development of a prototype liver and gall bladder anatomy lesson which was demonstrated at the MMVR 5 Conference held in San Diego in January, 1997.
   - After MMVR 5, the educational paradigm and necessary interface elements were modified to enable a case-based organization of materials within "Anatomic VisualizeR©". (The video made for IMAGE 97 conference held in July 1997 reflects these changes.)

3. *Software architecture expanded and enhanced:*

   - The software architecture was refined and expanded and performance was improved. VisualizeR's flexible environment now loads device drivers at run-time and exploits X resources to allow most changes to the environment to occur without needing to re-compile the application.

4. *Hardware upgraded -- VR devices acquired and integrated into application:*

   - Using funds from recently awarded DURIP grant [ONR N00014-97-1-0356] for effort entitled "3-D Perception Metrics for VE-Based Training Systems"
     - SensAble™ Technologies' PHANToM™: haptic force-feedback device installed. Research has begun on how to integrate collision detection methods into VisualizeR.
     - Immersion Corporation's MicroScribe-3-D : haptic non-force-feedback device installed. Currently, we can turn on and off this device within world, make a stylus icon appear, and use it with the Fakespace Pinch Gloves to pick objects in the virtual world.
     - Virtual Research's V6 Head Mounted Display: VGA quality HMD display
   - Using funds from DARPA grant targeted for upgrading the Silicon Graphics Incorporated (SGI) Onyx Reality Engine II development system
     - SGI Multi-Channel-Output (MCO): installed to enable simultaneous multiple displays; a prerequisite for supporting HMDs.
     - R10K CPU processor upgrade: to increase processing speed
     - Added 2 Raster Manager (RM) boards. to increase rendering speed

5. *New requirements for anatomic model decimation articulated:*

- Revised requirements for: 1) models to fit with respect to each other and 2) minimizing the amount of polygons without sacrificing realism. Negotiations between UCSD and Visible Productions occurred during a trip to facility in March 1997.
- Models decimated under revised schema are being incorporated into Anatomic VisualizeR© as they are received from Visible Productions.

6. *New three dimensional (3-D)exploratory tools designed and developed:*

- Cut-plane viewer: enables anatomic models (singly or in groups) to be dynamically visualized in cross section and with cuts made in any 3-D plane.
- 3-D space drawing tool: allows user to draw/trace using a ribbon of color which can remain in the world as an annotating element.
- Flag marking tool: permits sub-structures to be marked for testing or comment.
- 3-D ruler: allows user to measure anatomic structures

7. *Study Guide reorganized :*

- New 3-D notebook paradigm provides for syllabus materials, as well as personal pages.
- Pages of interest can be duplicated and moved into the virtual world.
- Tabs organize lesson sections.
- Buttons access ancillary materials at the user's discretion.

8. *Approval received from UCSD Human Subjects Committee*

- Plans to perform 3-D perception testing on student subjects were approved in November, 1997.
- Revised test plans are being submitted for review. In addition to the already specified Kennedy Simulator Sickness Questionnaire, the following performance measures will be added:
  - Cognitive and physical workload as indexed by the National Aeronautics and Space Administration (NASA) Task Load Index (TLX) workload measurement instrument
  - Fatigue as indexed by the Yoshitake Fatigue Scale
  - Duration of task performance (from "go" signal to successful completion of task)
  - Accuracy of performance as indexed by the number and type of errors made in the performance of the task.

9. *Staffing Changes:*

- Ram Prayaga left the project due to his doctoral research requirements.
- Mark Danks moved to the SF Bay area for personal reasons. He continues to be available to this project on a consulting basis.
- Margaret Murray is returning to this project full-time as soon as a replacement can be found for her other responsibilities.
- UCSD Computer Science major Robert Curlee III was hired in June 1997. He worked full-time during the summer, and continues half-time during the school year.

SUMMARY:

VR-MMS software architecture has been formalized, expanded and enhanced. VR hardware devices have been acquired and integrated into the system prototype. Prototype case-based anatomy lessons are being designed using faculty input. As the prototype system matures, the primary goal shifts to completion of the basic evaluation phase of this project. During the upcoming one year, no-cost extension to this grant, student subjects will be run through tests to assess the effect of level of immersion and virtual environment feature layout on their performance. Both perceptual and learning outcomes testing will be carried out.

PAPERS PUBLISHED:

1. Hoffman, HM, M Murray, M Danks, R Prayaga, AE Irwin, and D Vu. 1997. "A Flexible and Extensible Object-Oriented 3-D Architecture: an Application in the Development of Virtual Anatomy Lessons." In *Medicine Meets Virtual Reality - Global Healthcare Grid*, edited by K. Morgan, H. Hoffman, D. Stedney and S. Weghorst. Amsterdam: IOS Press. (39):461-466.

2. Hoffman, HM, AE Irwin, R Prayaga, M Danks, and M Murray. 1996. "Virtual Anatomy from the Visible Man: Creating Tools for Medical Education." Paper read at First Visible Human Project Conference, October 7-8, 1996, at Bethesda, MD.

PRESENTATIONS: (ALL OR PART CONCERNING Anatomic VisualizeR©)

1. Oct 7, 1996 "Virtual Anatomy from the Visible Man: Creating Tools for Medical Education." First Visible Human Project Conference, National Library of Medicine, Bethesda, MD.

2. Oct 11, 1996 "3-D & Virtual Reality" Grand Session and Workshop (with Mr. Thomas McCracken) Universidad Colegio Major de Nuestra Senora del Rosario, Bogota, Columbia. dr. Rafael Riveros D., MD Chancellor, Dr. Leonardo Palacios S., MD Medical Education

3. Nov 7, 1996. "Computers and Communication Technology in Graduate Medical Education". AAMC's Section on Resident Education (SRE) Luncheon Address at the 1996 AAMC Annual Meeting in San Francisco.

4. Jan 25, 1997. "A Flexible and Extensible Object-Oriented 3-D Architecture: an Application in the Development of Virtual Anatomy Lessons." Medicine Meets Virtual Reality 5, San Diego, CA.

5. Mar 25-27 1997 "Anatomic VisualizeR©" Invited demo at UC All-University Conference on Teaching and Learning Technologies. Held at the Anderson School on the UCLA campus.

6. July 6-9, 1997. "Teaching, Learning, and Information Technology" presented at Information Technology in the Academic Medical Center, AAMC Management Education Program, Snowmass, Colorado.

7. July 17, 1997. "Anatomic VisualizeR©: Status Report" IMAGE 97 DARPA Briefing. Phoenix, AZ.

8. Aug 4-8, 1997. "Teaching, Learning, and Information Technology: An American Perspective", invited talk at Revolution 97 - Towards the Smart Community. Adelaide Convention Centre, Adelaide, Australia